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(19)(CA) **CANADIAN PATENT** (12)

(54) Method of Producing Wheels of Light Alloy

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(57) 6 Claims

47331d

Abstract

A method of producing wheels of light alloy is characterized in that in producing one-piece forged type wheels of such a light alloy as aluminum alloy or magnesium alloy, a light blank is die forged, whereby a required pattern defined by ribs is formed on a disc while an outer rim outwardly projecting axially of the wheel is formed around the outer periphery of the disc simultaneously with the formation of said disc.

METHOD OF PRODUCING WHEELS OF LIGHT ALLOY

TECHNICAL FIELD

This invention relates to a method of producing automobile wheels of such a light alloy as aluminum alloy or magnesium alloy, and more particularly it relates to a method of producing one-piece forged type wheels of light alloy, wherein on the outer periphery of the wheel disc formed with a predetermined pattern defined by ribs, the inner and outer rims projecting in opposite directions axially of the wheel are integral with the disc.

BACKGROUND ART

A method of producing automobile wheels of such a light alloy as aluminum alloy or magnesium alloy, particularly a method of producing one-piece wheels of light alloy wherein on the outer periphery of the wheel disc, the inner and outer rims projecting in opposite directions axially of the wheel are integral with the disc, is disclosed in Japanese Patent Application Disclosure No. 26648/1981.

A conventional method commonly used in producing such one-piece forged type wheels of light alloy having rims integral with the disk will now be described with reference to the accompanying drawings.

To enable the prior art to be described with the aid of diagrams, the figures of the drawings will first be listed.

Fig. 1 is a sectional view showing how an outer rim is formed by die forging;

Fig. 2 is a front view showing an upper-die exchanging device installed in a press;

Fig. 3 is a front view showing a portion of a reticulate pattern formed on a disc;

Fig. 4 is a front view showing a disc having a spoke pattern;

Fig. 5 is a front view showing a disc having a simple pattern;

Fig. 6 is a sectional view of a light alloy blank die-forged to form a disc of less undulating pattern and an outer rim;

Fig. 7 is a sectional view of a light alloy blank die-forged to form a disc of more undulating pattern with ribs curved axially of the wheel and to form an outer rim;

Fig. 8 is a sectional view showing how to spin an inner flange disposed around the outer periphery of a disc having more undulating pattern;

Fig. 9 is a sectional view showing how to flare the inner flange spinned as shown in Fig. 8;

Fig. 10 is a sectional view showing how to re-spin the inner flange flared as shown in Fig. 9;

Fig. 11 is a front view of a device for opening

unnecessary thin-walled portions between ribs on a disc;

Fig. 12 is an enlarged flagmentary sectional view showing how to open thin-walled portions by the device of Fig. 11;

Fig. 13 is a sectional view of a wheel with a disc having a less undulating pattern;

Fig. 14 is a sectional view of a wheel with a disc having a more undulating pattern;

Fig. 15 is a sectional view of a light alloy blank forged into a substantially H-shaped cross-section wherein the disc has a less undulating pattern;

Fig. 16 is a sectional view showing how to spin the outer flange disposed around the light alloy blank of Fig. 15 into an outer rim of required shape;

Fig. 17 is a sectional view showing how to spin an inner flange into an inner rim of required shape after forming an outer rim around the outer periphery of a disc having a less undulating pattern; and

Fig. 18 is an enlarged fragmentary front view showing how a more undulating pattern on a disc deforms.

Conventionally, in producing such a wheel, a light

alloy blank 1 obtained by cutting into required lengths a cylindrical material produced by continuous casting is used and said light alloy blank 1 is formed by forging, as shown in Fig. 15, into a substantially H-shaped cross-section having flanges 2 and 3 on the outer periphery of a disc 11, said flanges projecting in opposite directions axially of the wheel, said disc being formed with a required pattern defined by thick-walled ribs 14 and thin-walled portions 15 between said ribs 14. Subsequently, the thus formed flange 2 outwardly projecting around the outer periphery of the disc 11 is formed into an outer rim 12 of suitable shape as shown in phantom lines in Fig. 15. To this end, as shown in Fig. 16, a mandrel 20 is disposed on the inner side of the disc 11 and a center thrust rod 21 is disposed on the outer side of the disc 11, said mandrel 20 and said center thrust rod 21 cooperating with each other to clamp said disc 11 therebetween so that the light alloy blank 1 may be rotated with the rotation of the mandrel 20, while a pair of stepped rollers 22 and 23 are disposed in opposed relation to each other on the outer and inner sides of said flange 2, respectively, so as to clamp the flange 2 between said rollers 22 and 23, the arrangement being such that while rotating the light

alloy blank 1 at a speed usually of 300-400 rpm by said mandrel 20, said rollers 22 and 23 are moved to deform the outer flange 2 into the outer rim 12 of required shape.

After the flange 2 has been formed into the outer rim 12 in this manner, the flange 3 inwardly projecting around the outer periphery of the disc 11 is formed into an inner rim 13 as shown in phantom lines in Fig. 15. To this end, as shown in Fig. 17, a mandrel 31 having an outer peripheral shape corresponding to the shape of the inner rim 13 is disposed on the inner side of the disc 11 and a holder mandrel 32 is disposed on the outer side of the disc 11, said mandrels 31 and 32 cooperating with each other to clamp the disc 11 therebetween; thus, the light alloy blank 1 is rotated with the rotation of the mandrels 31 and 32 while, as shown in Fig. 17, a roller 33 for rolling operation disposed on the outer periphery of the inner flange 3 is moved along the inner mandrel 31 while being pressed against the flange 3, thereby forming the flange 3 into the inner rim 13 of required shape.

Thereafter, unnecessary thin-walled portions 15 between the ribs 14 on the disc 11 are removed as by punching on a press, cutting on a lathe, or end milling on a milling machine, thereby producing a one-piece wheel

of light alloy wherein on the outer periphery of the disc 11 having a required disc pattern, the rims 12 and 13 projecting in opposite directions axially of the wheel are integral with the disc 11.

In such wheel, however, the rise angle α of the outer rim 12 at which it rises from the outer periphery of the disc 11 is generally 65-80 degrees. In the case of conventional forming, if the traveling speed of said rollers 22 and 23 clamping the outer flange 2 therebetween is increased to shorten the forming time, excessive forces will act on said rollers 22 and 23 and the flange 2, thus offering a problem that they are damaged or the outer rim 12 is warped to a great extent. On the other hand, if the traveling speed of the rollers 22 and 23 is reduced, there arises a problem that much time is involved in forming the outer rim 12. Additionally, when the flange 2 on the light alloy blank 1 which is rotated as described above is deformed while being clamped between the rollers 22 and 23, strains are produced in the outer rim 12 owing to a rotational sway, degrading the circularity of the outer rim 12; for example, in the case of a wheel having a diameter of 15 inches, an error of as much as 2.5-3 mm occurs in the diameter. Thus, there has been a problem that the outer rim 12 cannot be accurately formed.

The conventional mandrels 31 and 32 for clamping the inner rim 13 therebetween are substantially flat at their end surfaces, offering no particular problem in producing a wheel having a less undulating disc 11 as shown in Fig. 13. Today, however, wheels with discs 11 having various patterns are demanded; thus, in producing a wheel having a greately undulating disc 11 as shown in Fig. 14 in which ribs 14 forming a pattern on the disc 11 are greately curved axially of the wheel, if the inner rim 13 is formed using a roller 33 for rolling operation by clamping the undulating disc 11 between the mandrels 31 and 32 whose end surfaces are flat and rotating the light alloy blank 1, as in the conventional manner, then the torque on the light alloy blank 1 cooperates with the pressing force of the rolling roller 33 to warp or distort the ribs 14, as shown in phantom lines in Fig. 18, thus disfiguring the pattern on the disc 11. Additionally, where the rolling roller 33 is pressed against the flange 3 to roll the latter along the inner mandrel 31, when the rolled flange 3 reaches the rise portion 31a of the mandrel 31, it becomes difficult for the roller to perform any further rolling, thus leaving the rise portion of the rim 13 incomplete.

Further, in removing unnecessary thin-walled portions

15 between the ribs 14 on the disc 11, the use of conventional punching on a press makes it necessary to prepare a number of dies according to a pattern to be formed on the disc 11, resulting in a high cost for such dies. Moreover, in the case of a disc 11 having a complicate pattern or a disc 11 having heavy undulations, it is very difficult to punch out such thin-walled portions 15. Further, cutting on a lathe or milling on a milling machine is low in efficiency of operation, and particularly milling on a milling machine takes much time in making many holes. A further problem is that these machining operations involve much loss of material.

DISCLOSURE OF INVENTION

This invention has been accomplished with a view to solving the aforesaid problems encountered in producing one-piece forged type automobile wheels of light alloy using a light alloy blank such as aluminum alloy or magnesium alloy, wherein the disc and the rims on the outer periphery thereof are integral.

In a production method according to this invention, an outer rim which rises at a sharp angle on the outer periphery of the disc of the wheel on the axially outer side of the wheel is formed by die forging simultaneously with a pattern on the disc; thus, the formation of an

outer rim can be effected in a simple manner and in a short time together with the formation of a pattern on the disc, while ensuring high degrees of circularity and dimensional accuracy of the outer rim. Further, in performing such die forging using some types of upper and bottom dies, the invention provides an arrangement comprising a guide rail disposed in the upper region of a press, and an attaching block adapted to travel along said guide rail and having some types of upper dies attached to the lower surface thereof for successive exchange of upper dies so as to effect exchange of upper dies simply and in a short time.

Further, in this invention, after the outer rim has been formed by die forging together with the pattern on the disc, as described above, the disc is clamped between a pair of mandrels and a flange projecting inwardly around the outer periphery of the disc is formed by spinning into an inner rim of required shape. In this connection, in the case where the ribs which form the pattern on the disc are curved axially of the wheel and have an undulating pattern, at least one of the mandrels clamping the disc therebetween is so shaped that part or the whole of the end surface thereof for clamping the disc has a shape corresponding to the undulating pattern on the disc surface. The end surface of such mandrel is fitted to the undulating pattern

on the disc so that the disc is clamped between the pair of mandrels, thereby preventing deformation of the disc during forming the inner rim by spinning.

Further, in this invention, in clamping the disc between a pair of mandrels and rolling the inwardly projecting flange on the outer periphery of the disc by a rolling roll along the outer peripheral surface of the inner mandrel so as to form an inner rim, as described above, the end portion of the rolled flange is outwardly flared as by a press according to the need, the thus flared flange being pressed against the mandrel by the rolling roller again, thereby facilitating the formation of inner rim whose end edge is raised. Further, in spinning the inner rim in this manner, a rolling roller having a central circumferential groove formed on the roll surface is used, so that simultaneously with the formation of the inner rim, tire fixing ridges are formed at required positions adjacent said outer and inner rims by said rolling roller having said groove.

Additionally, in this invention, unnecessary thin-walled portions present between ribs formed on the disc by said die forging are opened by plasma cutting; thus, even if the disc has a complicate pattern or is heavily undulating, such thin-walled portions can be easily opened.

BEST MODE OF CARRYING OUT THE INVENTION

An embodiment of this invention wherein a blank of light alloy such as aluminum alloy or magnesium alloy is forged to produce a one-piece forged type

automobile wheel of light alloy in which the disc and rims are integral with each other, will now be described with reference to the accompanying drawings.

In this embodiment, use is made of a light alloy blank 1 obtained by cutting into required lengths a long cylindrical form of light alloy such as aluminum alloy or magnesium alloy usually produced by continuous casting for use as blanks for wheels. This light alloy blank 1, as shown in Fig, 1, is pressed between upper and bottom dies 41 and 42 of required shape, whereby a disc 11 is formed with a required disc pattern defined by thick-walled ribs 14 and thin-walled portions 15 disposed between said ribs 14 and the formation of an outer rim 12 outwardly projecting axially of the wheel and around the outer periphery of the disc 11 is effected simultaneously with the formation of said pattern on said disc 11.

The angle at which the outer rim 12 rises from the outer periphery of the disc 11 is 65-80 degrees, as previously described, which means that it is necessary to deform the light alloy blank 1 to a great extent. For this reason, the die forging operation using the upper and bottom dies 41 and 42 is generally performed hot by heating the light alloy blank 1. In this die forging, usually, some types of upper and bottom dies 41 and 42

are used and these upper and bottom dies 41 and 42 are successively exchanged to progressively deform the light alloy blank 1 so as to form the outer rim 12. In performing such die forging, in this embodiment, an arrangement is provided, as shown in Fig. 2, comprising a guide rail 43 horizontally installed in the upper region of a press 40, an attaching block 45 having traveling rollers 45 for travel along said guide rail 43, with some types (two types, in this embodiment) of upper dies 41 attached to the lower side of said attaching block 45, and a hydraulic cylinder 46 installed on the guide rail 43 for moving said attaching block 45 to exchange the upper dies 41. At a position where a positioning pin 47 fixed to the press 40 fits in a first engaging recess 48a formed in the attaching block 45, a first die 41 lies above a bottom die 42 fixed on a bed 49, while at a position where the attaching block 45 is locked by the positioning pin 47 fitting in a second engaging recess 48b formed in the attaching block 45, a second upper die 41 lies above the bottom die 42. In this manner, the upper dies 41 are exchanged to hot-forge the light alloy blank 1 by the first and second upper dies 41 and 42. Thus, with this arrangement, the upper dies 41 can be exchanged in a short time and the light alloy blank 1 can be die-forged continuously without

having to re-heat the light alloy blank 1 each time the die is exchanged.

The pattern to be formed on the disc 11 of the wheel is determined by the shapes engraved in the upper and bottom dies 41 and 42 to be used at the final forging step. Thus, any desired pattern may be formed; for example, a reticulate pattern shown in Fig. 3, a spoke pattern shown in Fig. 4, and a simple pattern shown in Fig. 5 may be formed. Further, such pattern on the disc 11 is not limited to a less undulating one shown in Fig. 6; a heavily undulating pattern, as shown in Fig. 7, may be formed wherein ribs 14 forming the pattern are greately curved axially of the wheel.

After the pattern on the disc 11 and the outer rim have been formed in this manner, the flange 3 projecting axially inwardly of the wheel is formed by spinning into an outer rim 13 of desired shape.

As shown in Fig. 6, in the case where an inner rim 13 is formed around the outer periphery of the disc 11 having a less undulating pattern with ribs 14 on the disc 11 curving to a small extent, as in the prior art as shown in Fig. 17 a mandrel 31 having an outer peripheral shape corresponding to the shape of the outer rim 13 to be formed is disposed on the inner

side of the disc 11 and a holder mandrel 32 is disposed on the outer side of the disc 11 and the latter is clamped between said pair of mandrels 31 and 32 whose end surfaces are substnatially flat, the mandrels 31 and 32 together with the disc 11 being rotated at a speed usually of 300-400 rpm by an electric motor through a speed change device. A rolling roller 33 disposed on the outer periphery of the inner flange 3 is controlled as by a hydroelectric servo or hydraulic servo so that the inner flange 3 on the rotating light alloy blank 1 is squeezed by the rolling roller 33, the flange 3 being rolled along the inner mandrel 31.

However, as shown in Fig. 7, in the case where ribs 14 forming a pattern on the disc 11 are greately curved axially of the wheel and an inner rim 13 is to be formed around the outer periphery of a disc having a heavily undulating pattern, if the disc 11 is clamped by a pair of mandrels 31 and 32 whose end surfaces are subatantially flat so as to spin the inner flange 3, as described above, the disc 11 would deform as in the prior art. Thus, in an embodiment shown in Fig. 8, a pair of mandrels 31 and 32 whose end surfaces are shaped to correspond to the undulating pattern on the disc 11 are used, and the undulating end surfaces of these mandrels 31 and 32 are fitted to the undulating pattern on the

disc 11 to clamp the disc 11 between the mandrels 31 and 32. In this state, the light alloy blank 1 is rotated together with these mandrels 31 and 32, as described above, and the inner flange 3 ia rolled by the rolling roller 33. In this case, even if a torsional force resulting from a combination of the torque on the light alloy blank 1 and the pressing force of the rolling roller 33 acts on the disc 11, deformation of the pattern on the disc 11 is prevented by the mandrels 31 and 32 whose end surfaces fit to the undulating pattern on the disc 11. In addition, in this embodiment, where the inner flange 3 is to be spinned around the outer periphery of the disc 11 having a heavily undulating pattern, only an example has been shown using a pair of mandrels whose end surface are shaped to correspond to the undulating pattern on the disc 11. However, in the case where the disc 11 has a heavily undulating pattern when the outer rim 12 is to be spinned around the outer periphery of the disc 11, as in the prior art, it is, of course, possible to use such mandrels 31 and 32 to clamp the disc therebetween so as to prevent deformation of the pattern on the disc 11.

Further, in the case of forming the inner rim 13 by clamping the disc 11 between the mandrels 31 and 32, rotating the light alloy blank 1 together with the mandrels 31 and 32, and rolling the inner flange 3 along the inner

mandrel 31 by the rolling roller 33, as described above, it may occur that the rolled flange 3 abuts against the rise portion 31a of the inner mandrel and is thereby prevented from being rolled any further and hence the end edge of the inner rim 13 cannot be raised. In such case, in this embodiment, after the flange 3 has been rolled to some extent by the rolling roller 33, the end of the rolled flange 3 is outwardly flared by upper and bottom mandrels 51 and 52, as shown in Fig. 9, until the end of the flange 3 passes over the rise portion 31a of the mandrel 31. After the end of the flange 3 has thus been flared, the disc 11 is clamped again between mandrels 31 and 32, as shown in Fig. 10, and is thereby rotated, while a rolling roller 33 presses the flared flange 3 against the inner mandrel 31 to form the inner rim 13 whose end is raised. In the example shown in Fig. 10, the rolling roller 33 for forming the inner rim 13 has a central circumferential groove 33b to circumferentially form tire fixing ridges 12a and 13a at required positions adjacent the outer and inner rims 12 and 13.

After the inner rim 13 has been formed as described above, unnecessary thin-walled portions 15 present between the ribs 14 on the disc 11 are opened, whereby, as shown in Figs. 13 and 14, a one-piece wheel of light alloy in which the disc 11 is integral with the rims 12

and 13 is produced.

In opening thin-walled portions 15, in this embodiment, a required number of light alloy blanks with their inner rims 13 formed in the manner described above are indexably positioned on a turntable 63 rotatably supported by rollers 62 installed on the upper ends of support legs 61, while an operating range is stored in the memory unit of a working robot 66 having an operating arm 64 with a plasma arc blow nozzle 65 attached thereto. The operating arm 64 of the working robot 66 is actuated on instructions from the memory unit to move the blowing nozzle 64, which blows off plasma arcs by which the unnecessary thin-walled portions 15 are cut and opened, as shown in Fig. 12. Therefore, even if the disc 11 has a complicate pattern or is curved, the unnecessary thin-walled portions 15 can be easily opened without deforming the pattern. In performing cutting by plasma arcs, a cutting current of 148 A (29-30 A during pilot arcing) is usually used, the cutting speed is 2 m/min, and compressed air at 6 kgf/cm^2 is used as cutting gas.

In addition, it is not absolutely necessary that the opening of such thin-walled portions 15 succeed the formation of the inner rim 13; it may precede the formation of the inner rim 13.

INDUSTRIAL APPLICABILITY

As has been described so far in detail, according to the present method of producing light alloy wheels, in producing one-piece forged type light alloy wheels using aluminum alloy or magnesium alloy wherein the disc is integral with the inner and outer rims projecting in opposite directions axially of the wheel, the formation of the outer rim rising at a sharp angle from the outer periphery of the disc is effected by die forging simultaneously with the formation of a pattern on the disc; thus, the outer rim can be formed in a short time and in a simple manner while ensuring high degrees of circularity and accuracy. In such die forging, in the case where a light alloy blank is heated and some types of upper and bottom dies are used to successively deform said light alloy blank, an arrangement is provided which comprises a guide rail installed in the upper region of a press, and an attaching block adapted to travel along said guide rail and having some types of upper dies attached to the lower side thereof, the attaching block being moved along the guide rail for successive exchange of upper dies, so that the exchange of upper dies can be made in a short time and in a simple manner without having to re-heat the light alloy blank each the die is exchanged, thereby ensuring continuous die forging.

Further, according to this invention, after the pattern on the disc and the outer rim have been formed by die forging as described above, the disc is clamped between a pair of mandrels and the light alloy blank is rotated together with the mandrels, while a flange projecting inwardly around the outer periphery of the disc is rolled along the outer peripheral surface of the inner mandrel by a rolling roller, wherepy said flange is formed by spinning into an inner rim of required shape. In this case, if the ribs forming a pattern on the disc are curved axially of the wheel and have an undulating pattern, at least one of the mandrels clamping the disc therebetween has a part or the whole of its end surface clamping the disc shaped to correspond to the undulating pattern on the disc, the end surface of such mandrel being fitted to the undulating pattern on the disc so as to clamp the disc between the pair of mandrels, thereby ensuring that the undulating pattern on the disc does not deform even in the case of forming by spinning an inner rim around the outer periphery of the disc having an undulating pattern.

In the case where the inner flange around the outer periphery of the disc is to be raised along the rise portion of the mandrel in forming said inner flange into an inner rim of required shape by the rolling roller as

described above, in this invention, the inner flange is rolled to a certain extent and then the end of the thus rolled flange is flared as by a press until it passes over the rise portion of the mandrel, whereupon the flared flange is pressed again by the rolling roller against the mandrel; in this manner, the inner rim whose end edge is raised can be easily formed. Further, in forming the inner rim by spinning in this manner, if a rolling roller having a central circumferential groove on its roll surface is used, the wheel can be circumferentially formed with tire fixing ridges at required positions adjacent the outer and inner rims by the groove of said rolling roller simultaneously with the formation of the inner rim.

Additionally, in this invention, thin-walled portions present between ribs formed on the disc by said die forging are opened by plasma cutting. Thus, even if the pattern on the disc is complicate or curved, such thin-walled portions can be easily opened without deforming the pattern on the disc.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of producing wheels of light alloy characterized in that in producing one-piece forged type wheels of such a light alloy as aluminum alloy or magnesium alloy, a light blank is die forged, whereby a required pattern defined by ribs is formed on a disc while an outer rim outwardly projecting axially of the wheel is formed around the outer periphery of the disc simultaneously with the formation of said disc.

2. A method of producing wheels of light alloy as set forth in claim 1, characterized in that in die forging said light alloy blank by using some types of upper and bottom dies to form around the outer periphery of the disc an outer rim outwardly projecting axially of the wheel, an arrangement is provided which comprises a guide rail horizontally installed in the upper region of a press, and an attaching block adapted to travel along said rail and having some types of upper dies attached to the lower side thereof, said attaching block being moved along the guide rail to successively exchange said upper dies.

3. A method of producing wheels of light alloy as set forth in claim 1 or 2, characterized in that when a flange inwardly projecting axially of the wheel is to be formed by spinning into an inner rim of required shape after said light alloy blank has been die forged to curve the ribs axially of the wheel to form an undulating pattern on the disc while forming the outer rim outwardly projecting

axially of the wheel around the outer periphery of the disc, at least one of a pair of inner and outer mandrels which clamp the disc therebetween has a part or the whole of its end surface shaped to correspond to the undulations on the outer surface and/or the inner surface of the disc, the disc is clamped by said mandrels and the light alloy blank is rotated together with said mandrels while the flange inwardly projecting axially of the wheel is rolled along the outer peripheral surface of the inner mandrel by a rolling roller into the inner rim of required shape.

4. A method of producing wheels of light alloy as set forth in claim 3, characterized in that when the flange inwardly projecting axially of the wheel and around the outer periphery of the disc is to be rolled along an outer peripheral surface of an inner mandrel by the rolling roller and is to be raised along the rise portion of the mandrel to be formed into the inner rim of required shape, said flange is rolled along the outer peripheral surface of the inner mandrel by the rolling roller to some extent and the end of the thus rolled flange is flared as by a press, whereupon the flared flange is pressed against the inner mandrel again by the rolling roller and is thereby raised along the rise portion of said mandrel thereby forming the inner rim whose end edge is raised.

5. A method of producing wheels of light alloy as set forth in claim 3, characterized in that when the flange inwardly projecting axially of the wheel and around the outer periphery of the disc is to be rolled along the outer peripheral surface of an inner mandrel by the rolling roller so as to be formed into the inner rim of required shape, the rolling roller has a central circumferential groove formed therein, so that tire fixing ridges are formed at required positions adjacent the outer and inner rims by the groove of said rolling roller.

6. A method of producing wheels of light alloy as set forth in claim 1 or 2, characterized in that unnecessary thin-walled portions formed on the disc by the die-forging of said light alloy blank are opened by plasma cutting.

FIG. 1

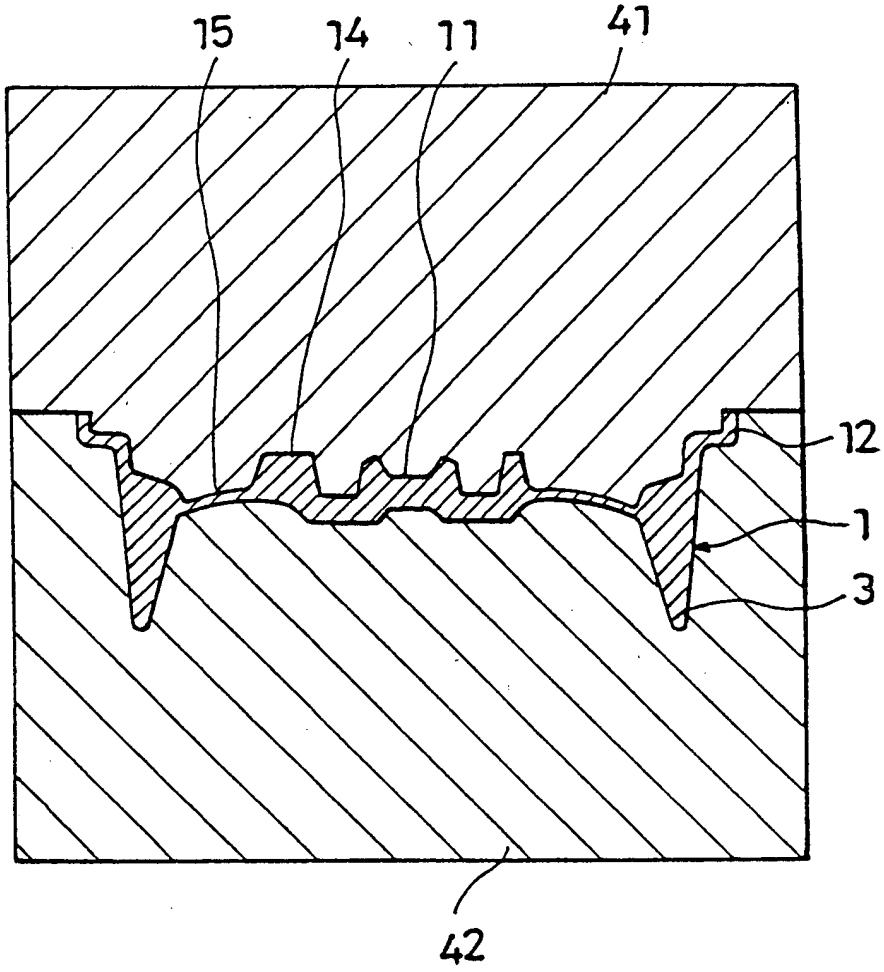
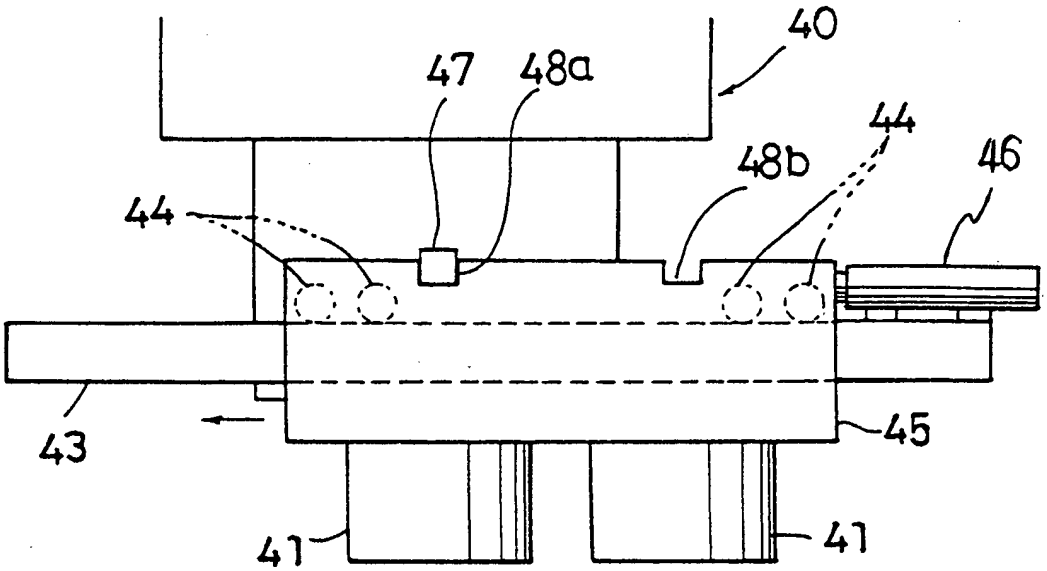


FIG.2



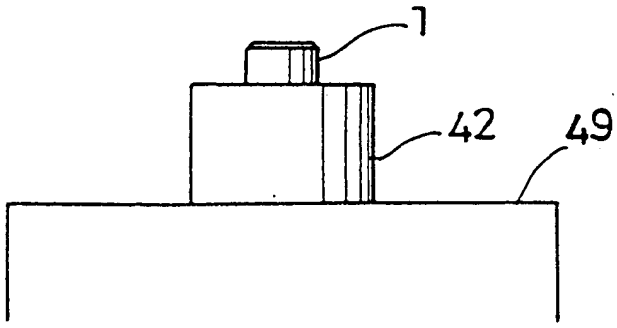


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FIG.3

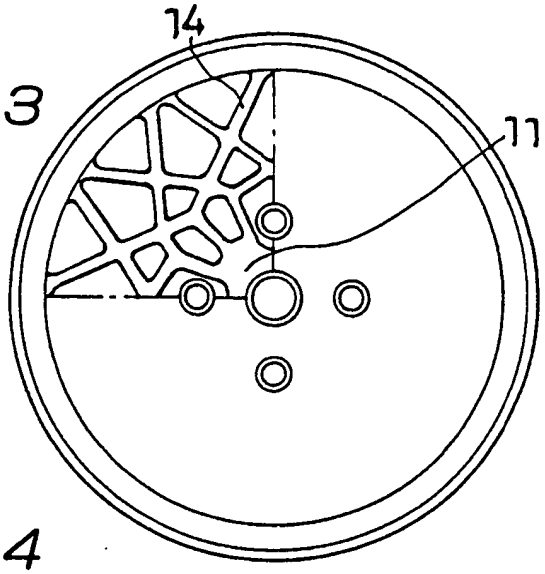


FIG.4

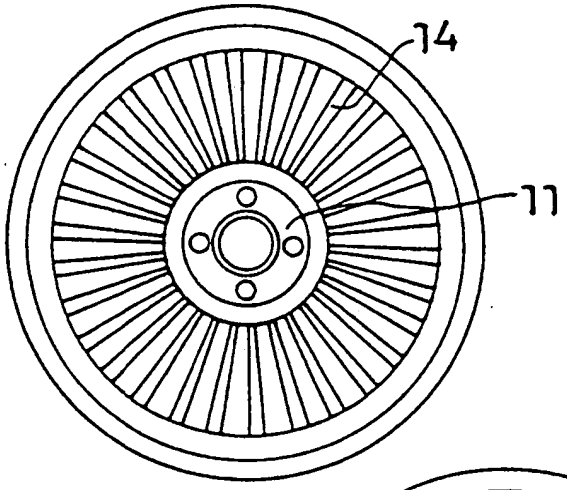
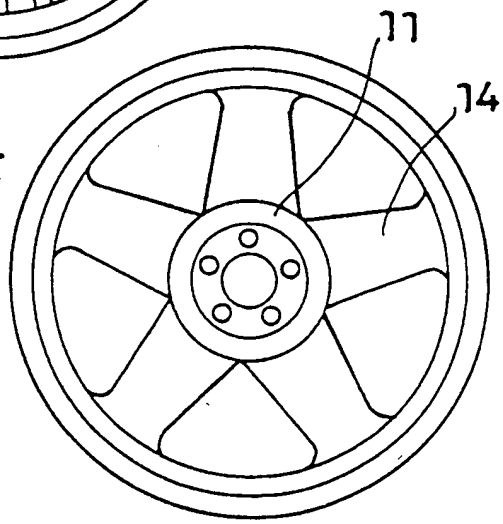


FIG.5



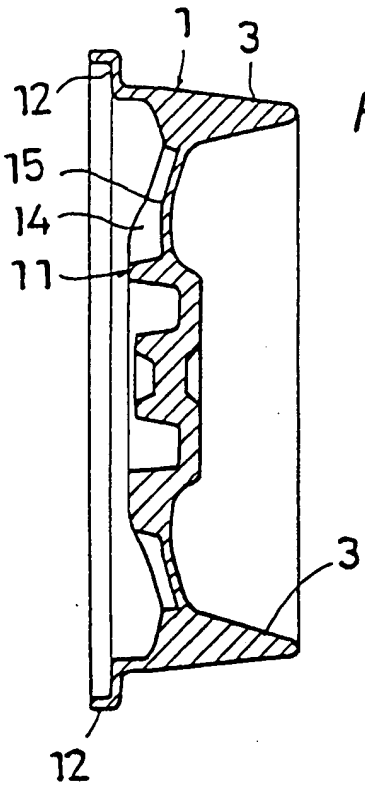


FIG.6

FIG.7

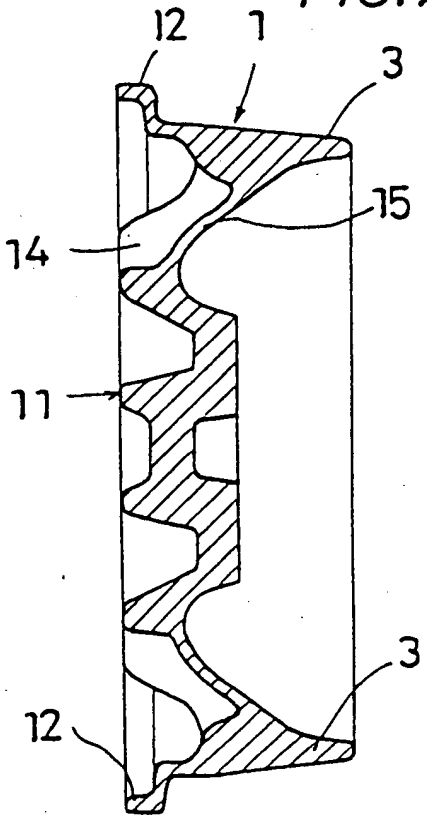


FIG.8

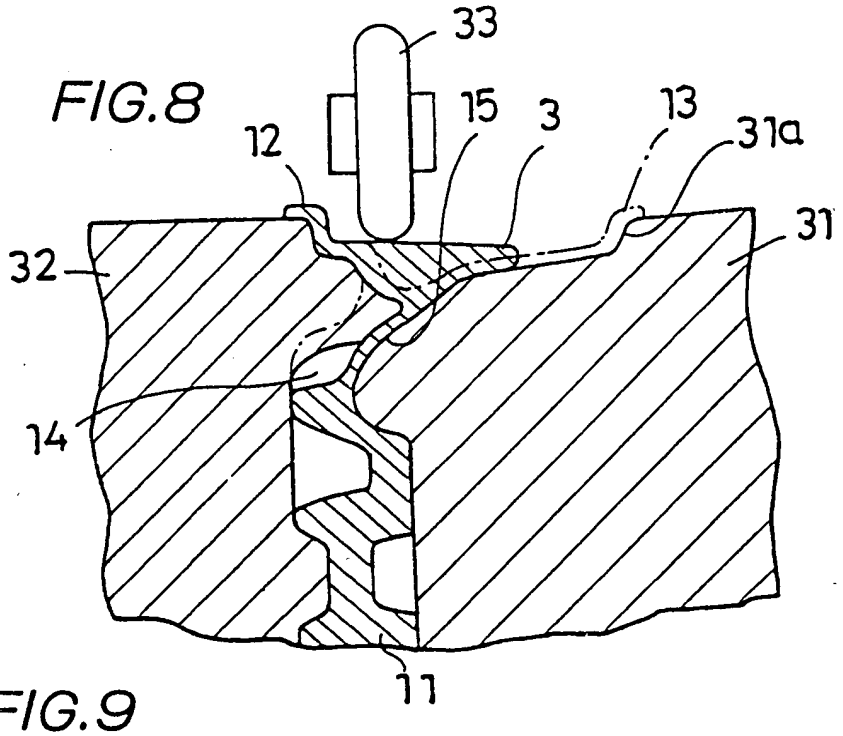


FIG.9

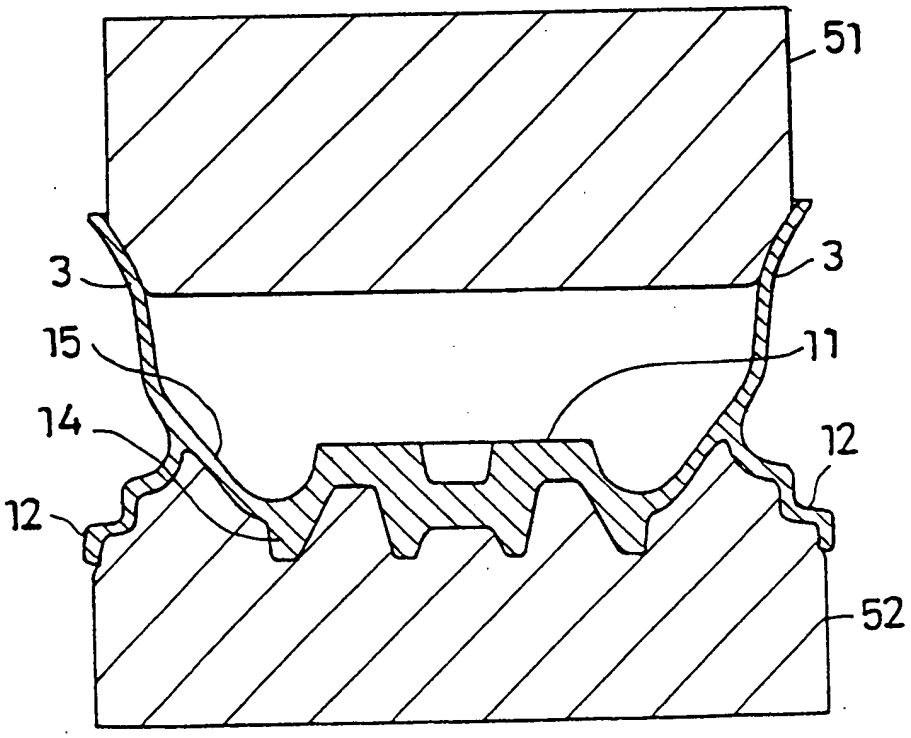


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FIG.10

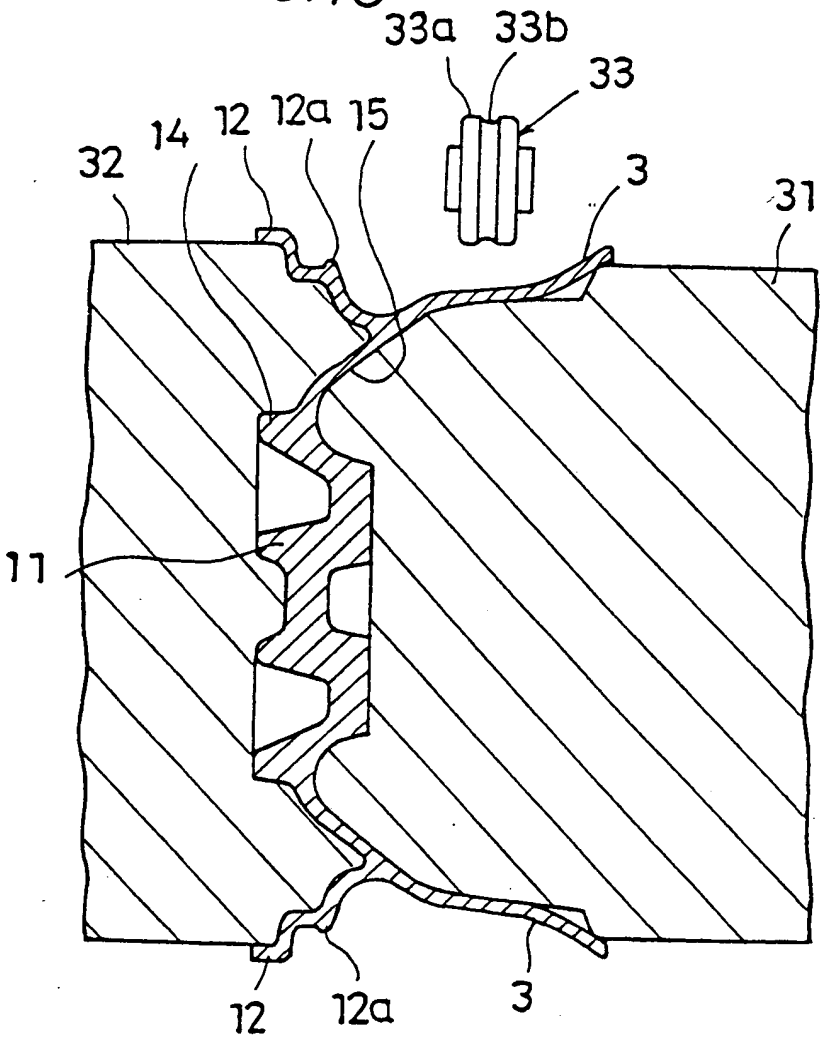


FIG.11

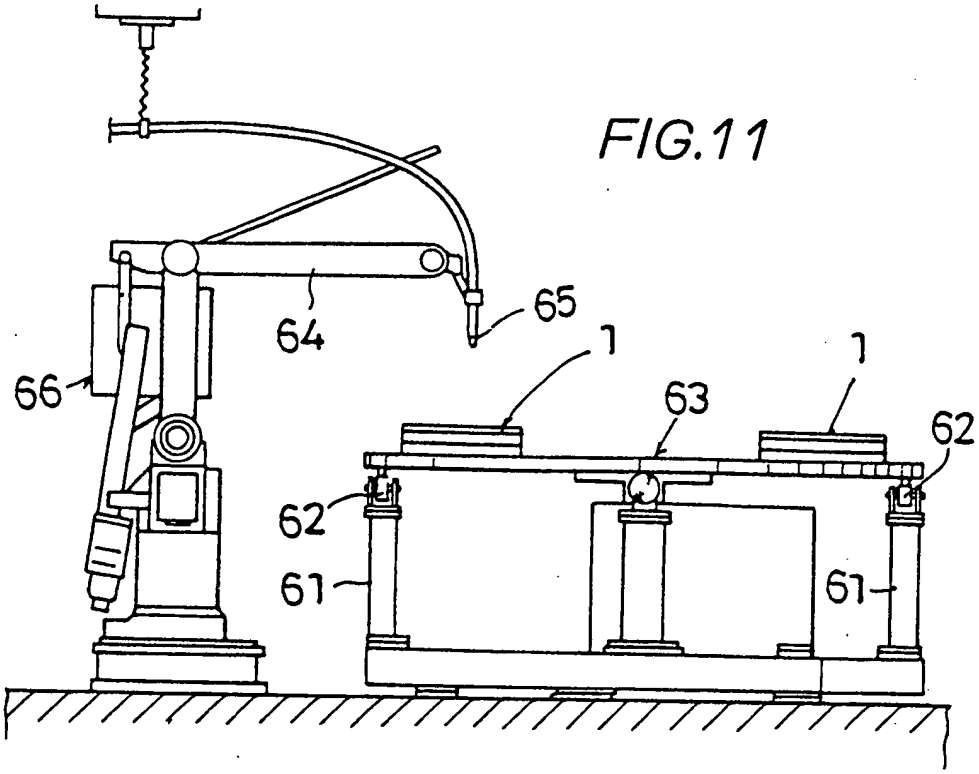
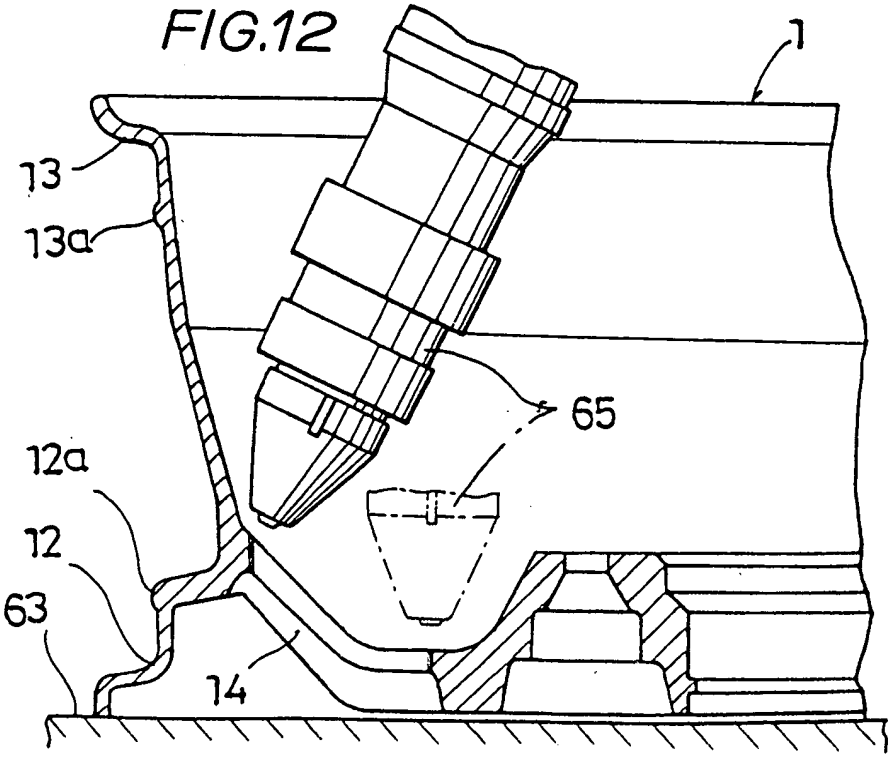


FIG.12



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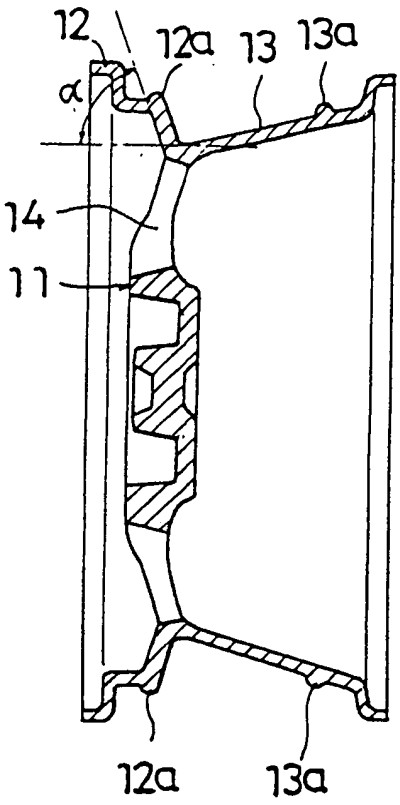
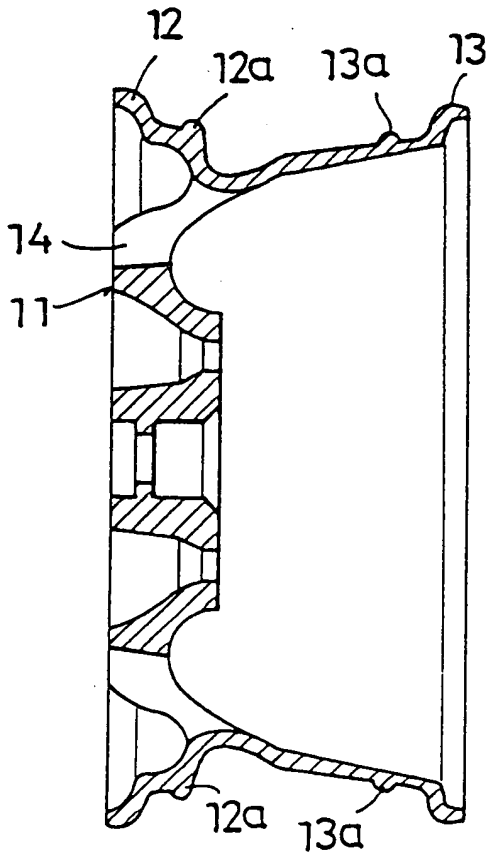


FIG.13

FIG.14



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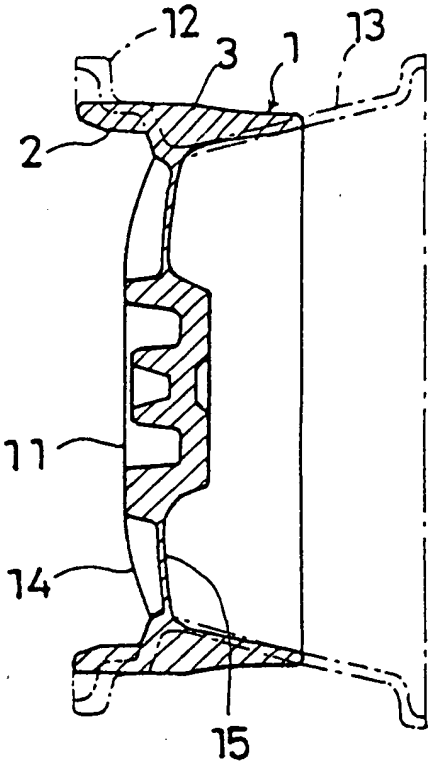

FIG.15

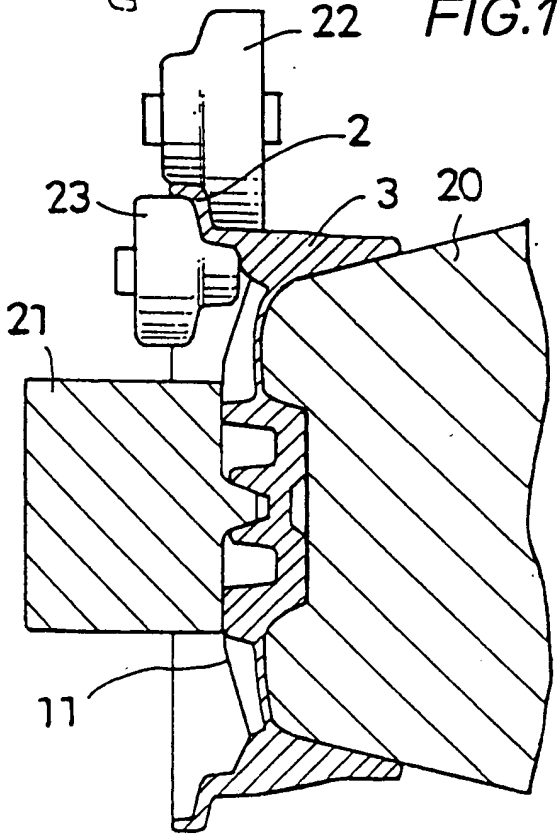

FIG.16

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FIG.17

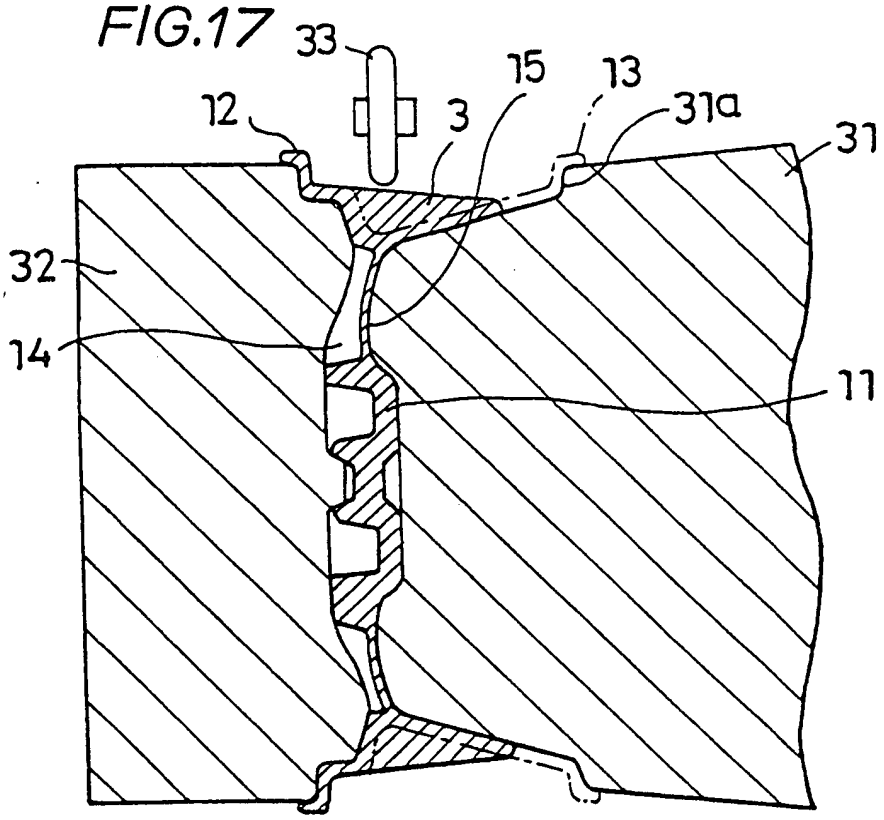
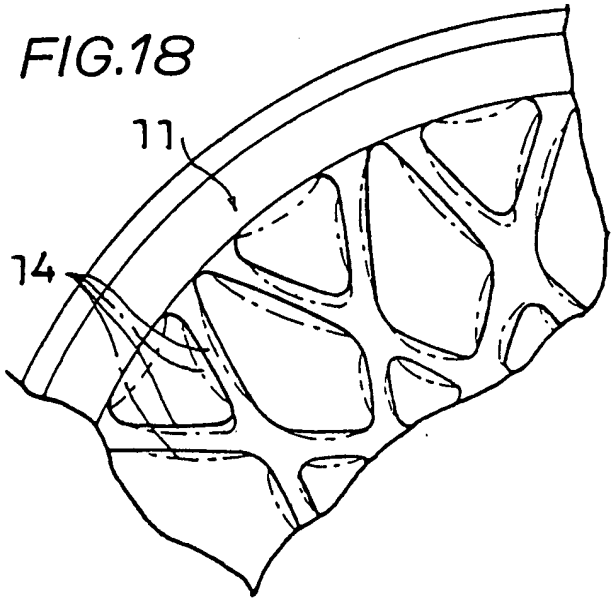


FIG.18



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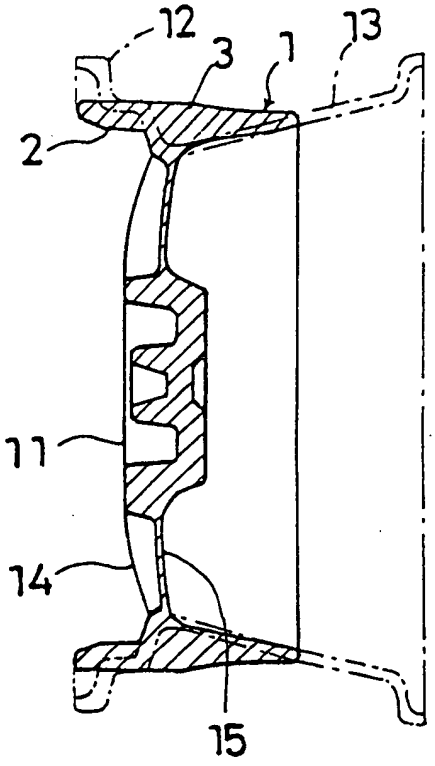
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